इंटरनेट मानक

Disclosure to Promote the Right To Information

Whereas the Parliament of India has set out to provide a practical regime of right to information for citizens to secure access to information under the control of public authorities, in order to promote transparency and accountability in the working of every public authority, and whereas the attached publication of the Bureau of Indian Standards is of particular interest to the public, particularly disadvantaged communities and those engaged in the pursuit of education and knowledge, the attached public safety standard is made available to promote the timely dissemination of this information in an accurate manner to the public.

"जानने का अधिकार, जीने का अधिकार"
Mazdoor Kisan Shakti Sangathan
"The Right to Information, The Right to Live"

"पुराने को छोड नये के तरफ"
Jawaharlal Nehru
"Step Out From the Old to the New"

IS 12762-8 (2010): Photovoltaic Devices, Part 8: Measurement of Spectral Response of A Photovoltaic (PV) Device [ETD 28: Solar Photovoltaic Energy Systems]

"ज्ञान से एक नये भारत का निर्माण"
Satyanarayan Gangaram Pitroda
"Invent a New India Using Knowledge"

Act Number 22 of 2005
The Indian Parliament
RIGHT TO INFORMATION

Made Available By
Public.Resource.Org

"ज्ञान एक ऐसा खजाना है जो कभी चुराया नहीं जा सकता है"
Bhartṛhari—Nītiśatakam
"Knowledge is such a treasure which cannot be stolen"

BLANK PAGE

BRUTUM FULMEN

IGNORANTIA JURIS NON EXCUSAT

PROTECTED BY COPYRIGHT

IS 12762 (Part 8) : 2010
IEC 60904-8 : 1998

भारतीय मानक

प्रकाशवोल्टीय युक्तियाँ

भाग 8 प्रकाशवोल्टीय (पी वी) युक्ति की वर्णक्रमीय प्रतिक्रिया (रेस्पोंस) का मापन

Indian Standard

PHOTOVOLTAIC DEVICES

PART 8 MEASUREMENT OF SPECTRAL RESPONSE OF A PHOTOVOLTAIC (PV) DEVICE

ICS 27.160

© BIS 2010

BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

January 2010 **Price Group 4**

Solar Photovoltaic Energy Systems Sectional Committee, ETD 28

NATIONAL FOREWORD

This Indian Standard (Part 8) which is identical with IEC 60904-8 : 1998 'Photovoltaic devices — Part 8: Measurement of spectral response of a photovoltaic (PV) device' issued by the International Electrotechnical Commission (lEC) was adopted by the Bureau of Indian Standards on the recommendation of the Solar Photovoltaic Energy Systems Sectional Committee and approval of the Electrotechnical Division Council.

The text of the I EC Standard has been approved as suitable for publication as an Indian Standard without deviations. Certain conventions are, however, not identical to those used in Indian Standards. Attention is particularly drawn to the following:

a) Wherever the words 'International Standard' appear referring to this standard, they should be read as 'Indian Standard'.

b) Comma (,) has been used as a decimal marker in the International Standard while in Indian Standards, the current practice is to use a point (.) as the decimal marker.

In this adopted standard, reference appears to certain International Standards for which Indian Standards also exist. The corresponding Indian Standards which are to be substituted in their respective places are listed below along with their degree of equivalence for the editions indicated:

International Standard	*Corresponding Indian Standard*	*Degree of Equivalence*
lEC 60904-1 : 1987[1]> Photovoltaic devices — Part 1: Measurements of photovoltaic current-voltage characteristics	IS 12762 (Part 1) :2010 Photovoltaic devices: Part 1 Measurement of photovoltaic current-voltage characteristics *(first revision)*	Technically Equivalent
lEC 60904-2 : 1989 Photovoltaic devices — Part 2: Requirements for reference solar cells	IS 12762 (Part 2): 1993 Photovoltaic devices: Part 2 Requirements for reference solar cells	Identical
lEC 60904-3 : 1989 Photovoltaic devices — Part 3: Measurement principles for terrestrial photovoltaic (PV) solar devices with reference spectral irradiance data	IS 12762 (Part 3) : 1998 Photovoltaic devices: Part 3 Measurement principles for terrestrial photovoltaic (PV) solar devices with reference spectral irradiance data	do
lEC 61646 :1996 Thin-film terrestrial photovoltaic (PV) modules — Design qualification and type approval	IS/I EC 61646:1996 Thin-film terrestrial photovoltaic (PV) modules — Design qualification and type approval	do

Only the English language text of the International Standard has been retained while adopting it in this Indian Standard, and as such the page numbers given here are not same as in the lEC Standard.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated expressing the result of a test, shall be rounded off in accordance with IS 2 :1960 'Rules for rounding off numerical values (revised). The number of significant places retained in the rounded off value should be the same as that of the specified value in the standard.

---

[1] Since revised in 2006.

IS 12762 (Part 8) : 2010
IEC 60904-8 : 1998

Indian Standard

PHOTOVOLTAIC DEVICES

PART 8 MEASUREMENT OF SPECTRAL RESPONSE OF A PHOTOVOLTAIC (PV) DEVICE

1 Scope

This part of IEC 60904 gives guidance for the measurement of the relative spectral response of both linear and nonlinear photovoltaic devices. This is only applicable to single-junction devices.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of IEC 60904. At the time of publication, the editions indicated were valid. All normative documents are subject to revision, and parties to agreements based on this part of IEC 60904 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

IEC 60904-1:1987, *Photovoltaic devices - Part 1: Measurement of photovoltaic current-voltage characteristics*

IEC 60904-2:1989, *Photovoltaic devices - Part 2: Requirements for reference solar cells*

IEC 60904-3:1989, *Photovoltaic devices - Part 3: Measurement principles for terrestrial photovoltaic (PV) solar devices with reference spectral irradiance data*

IEC 61646:1996, *Thin-film terrestrial photovoltaic (PV) modules - Design qualification and type approval*

3 Specific requirements for thin-film devices

3.1 Preliminary assessment of stability

Before the spectral response measurement of thin-film devices, the device under test shall be stabilized (if necessary), as specified in the light soaking test procedure (see IEC 61646).

3.2 Measurement under white bias light

The spectral response measurement shall be done under white bias light, similar to the AM 1,5 relative spectral distribution, at such a level that the spectral response does not significantly change when the bias level is reduced by 50 %.

3.3 Effect of voltage

Due to the effect of voltage, it is necessary to define the following terms:

- spectral response under load $(s_{v\lambda})$ the current density at a particular load voltage, generated by unit irradiance at a particular wavelength (A.W^{-1}), plotted as a function of wavelength;
- relative spectral response under load $(k_1 \cdot s_{v\lambda})$. the spectral response under load normalized to unity at wavelength of maximum response

$$k_1 \cdot s_{v\lambda} = s_{v\lambda}/s_{v\lambda max}$$

For thin-film devices, the spectral response measurement shall be done under the voltage which is appropriate to the intended use of the spectral response data. The voltage condition shall therefore be specified with the data.

4 Relative spectral response measurement

The relative spectral response of a photovoltaic (PV) device is measured by irradiating it by means of a narrow-bandwidth light source at a series of different wavelengths covering its response range, and measuring the short-circuit current density and irradiance at each of these wavelengths.

NOTE - In this standard, the words "light" and "sunlight" are used in their broader sense to include the ultra-violet and the infra-red as well as the visible spectrum.

The light source should irradiate the device uniformly and the temperature of the device should be controlled. The current densities are then divided by the irradiances or a proportional parameter and plotted as a function of wavelength. Alternatively, the irradiance may be kept constant (for instance, by varying the length of a monochromator exit slit), in which case the relative spectral response is obtained directly from the current density readings.

The irradiance monitor may be a vacuum thermocouple, a pyroelectric radiometer or other suitable detector. Another alternative is a previously calibrated reference photovoltaic device whose relative spectral response covers the required range. In this case, the relative spectral response of the test specimen is computed as follows:

$$k_2 \cdot s_{2\lambda} = k_1 \cdot s_{1\lambda} \cdot \frac{J_{mt\lambda}}{J_{mr\lambda}}$$

where

$k_1 \cdot s_{1\lambda}$ is the relative spectral response of the reference photovoltaic device at wavelength *k;*

$k_2 \cdot s_{2\lambda}$ is the relative spectral response of the test specimen at the same wavelength;

$J_{mr\lambda}$ is the measured short-circuit current density of the reference photovoltaic device at wavelength A.;

$J_{mt\lambda}$ is the measured short-circuit current density of the test specimen at the same wavelength.

In assembling the test set-up and performing the measuring, special attention should be given to the following:

- uniformity of irradiance at the test plane (uniform irradiance is very important when test specimen and reference photovoltaic devices are of different dimensions);

- filter transmission curves should be checked periodically to detect any "harmonic" transmission;
- load resistor calibration and contact resistance should be checked;
- linearity of response of the short-circuit current of the device versus the light intensity at all illumination levels and all wavelengths;
- the load resistor should be kept to a minimum practical value in order to remain as close as possible to true short-circuit conditions.

Figures 1 and 2 show two examples of test arrangements, the first embodying a quartz prism monochromator and the second a filter wheel as the monochromatic source.

NOTE - In this standard the word "monochromatic" is used to mean narrow bandwidth.

In both cases, the light source is a 1 000 W tungsten halogen lamp operated from a stable supply at a colour temperature of 3 200 K. The test cell and the irradiance monitor are mounted on opposite sides of a rotatable temperature-controlled block, so that either may be presented to the monochromatic beam in precisely the same place. Alternatively, they may be mounted on a slide with suitable positioning stops, or illuminated simultaneously by means of a beam splitter.

The filter wheel should contain a sufficient number of narrow-band filters to cover the response range of the cell in wavelength steps not exceeding 50 nm. The filters are arranged so that each can be indexed in turn between the light source and the test ceil or irradiance monitor. It is important that the filters should have negligible (under 0,2 %) side-bands. The monochromator is normally used with fixed slits and manually set to the same wavelength steps.

With crystalline silicon and other cells where the response has been shown to change linearly with irradiance, the short-circuit current of the cells (voltage drop across a standard 4-terminal fixed resistor) and the open-circuit voltage of the vacuum thermocouple or radiometer may be measured directly with a d.c. digital voltmeter or potentiometer. The requirements for instrumentation accuracy and the measurement of short-circuit currents given in IEC 60904-1 and IEC 60904-3 apply. If the d.c. method is used, the exit beam, test specimen and irradiance monitor should be completely enclosed in an anti-reflective light-tight box and meticulous precautions should be taken to avoid thermal and random electromagnetic fields which would cause errors. Alternatively, the exit beam may be chopped at a low frequency and the output voltages amplified and rectified. In this case, it is important to ensure that the amplifiers are linear and drift-free.

With non-linear devices it is necessary to use a chopped monochromatic beam, and to increase the irradiance to the desired operational level (e.g. 1 000 $W{\cdot}m^{-2}$) using unmodulated bias light from a suitable steady-state simulator as shown in figures 1 and 2. For linear devices the bias light is also necessary unless there is proof that the obtained spectral response will not change significantly when the bias light is not used.

A method for pulsed solar spectral response measurements is shown in figure 3. Apart from the change of light source, the measurement method remains the same, and is based on the comparison of the short-circuit currents generated by the cell to be measured and by the spectrally calibrated reference device. The test set-up comprises:

- a powerful flash lamp which provides high intensity light pulses;
- a filter wheel and light-tight box as previously described;

- a sample holder that ensures" reproducible positioning of the test specimen and the reference photovoltaic device;
- reference photovoltaic device(s) spectrally calibrated in accordance with IEC 60904-2 (specialized radiometry laboratories are best equipped to perform this calibration);
- a decade load resistor;
- an electronic "peak-detector";
- a digital voltmeter.

NOTE - The pulsed light method cannot be used on test specimens whose response time is too slow. Therefore, it must be verified that the same short-circuit current density is obtained from pulsed and steady-state light sources having the same intensity. This same requirement also applies to the reference device.

In assembling the test set-up and in performing the measurements, special attention should be given to the light pulse intensity monitoring and the subsequent reading correction which may either be manual or, better, automatic.

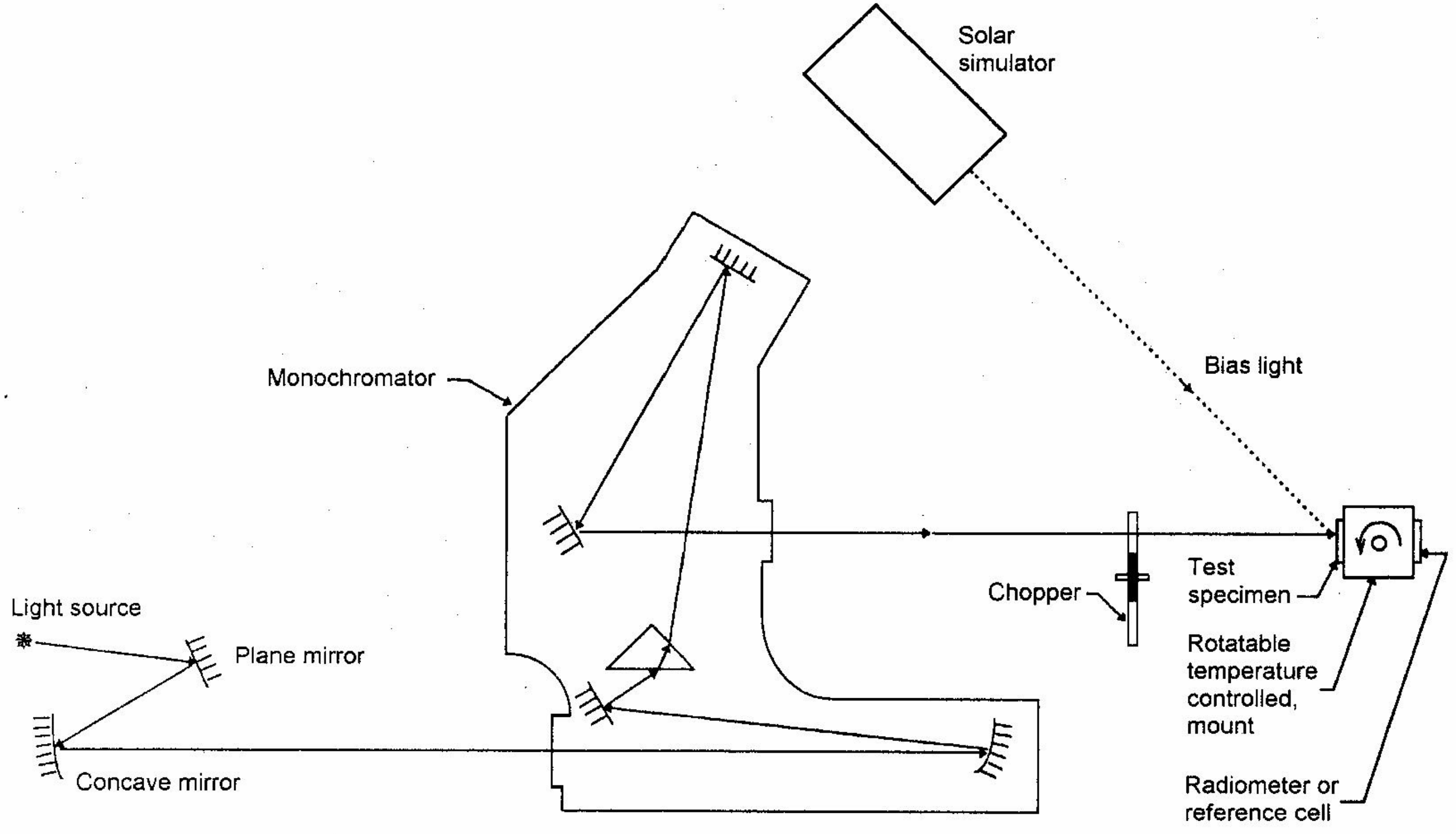

Figure 1 – Spectral response measurement using a monochromator

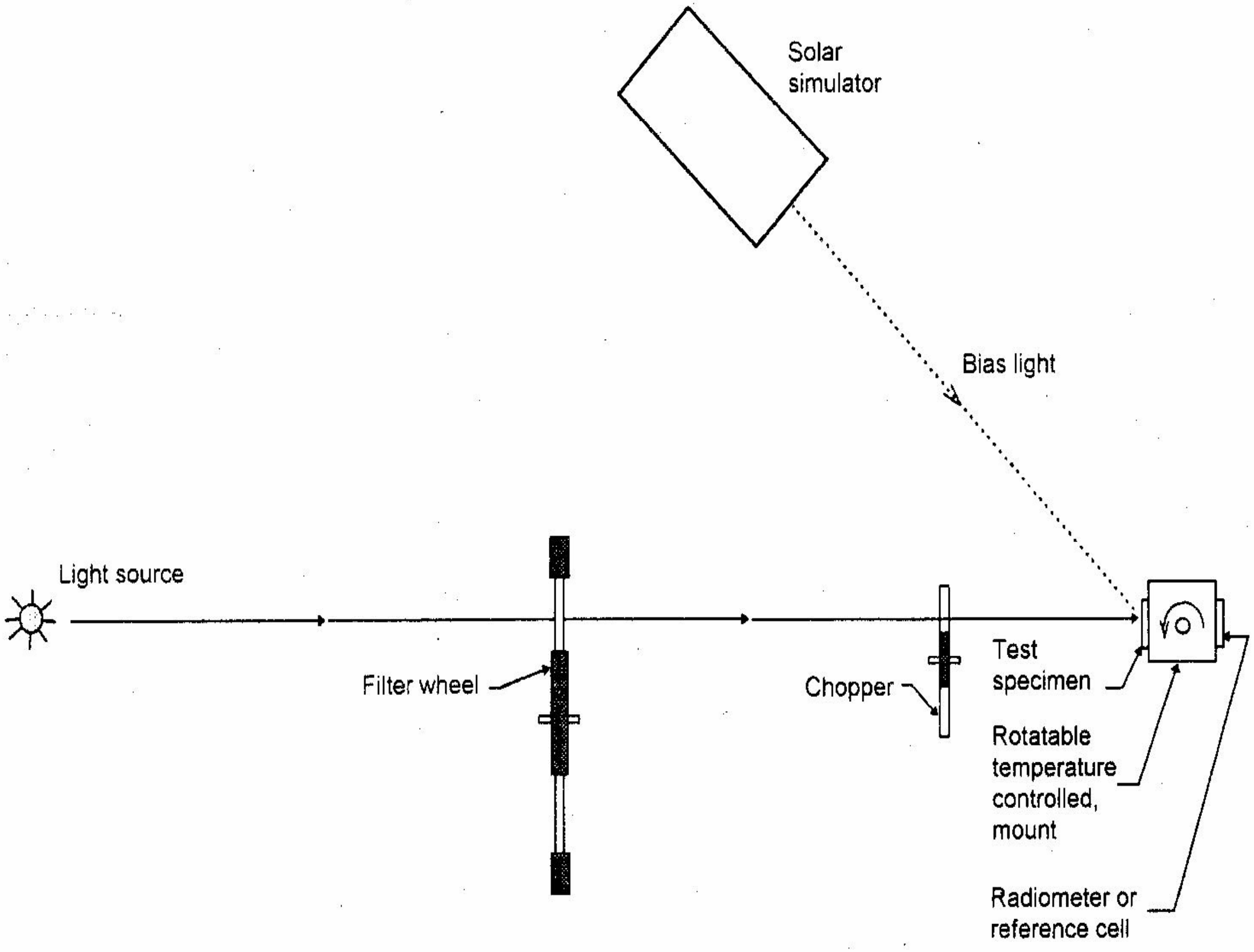

Figure 2 – Spectral response measurement using a filter wheel

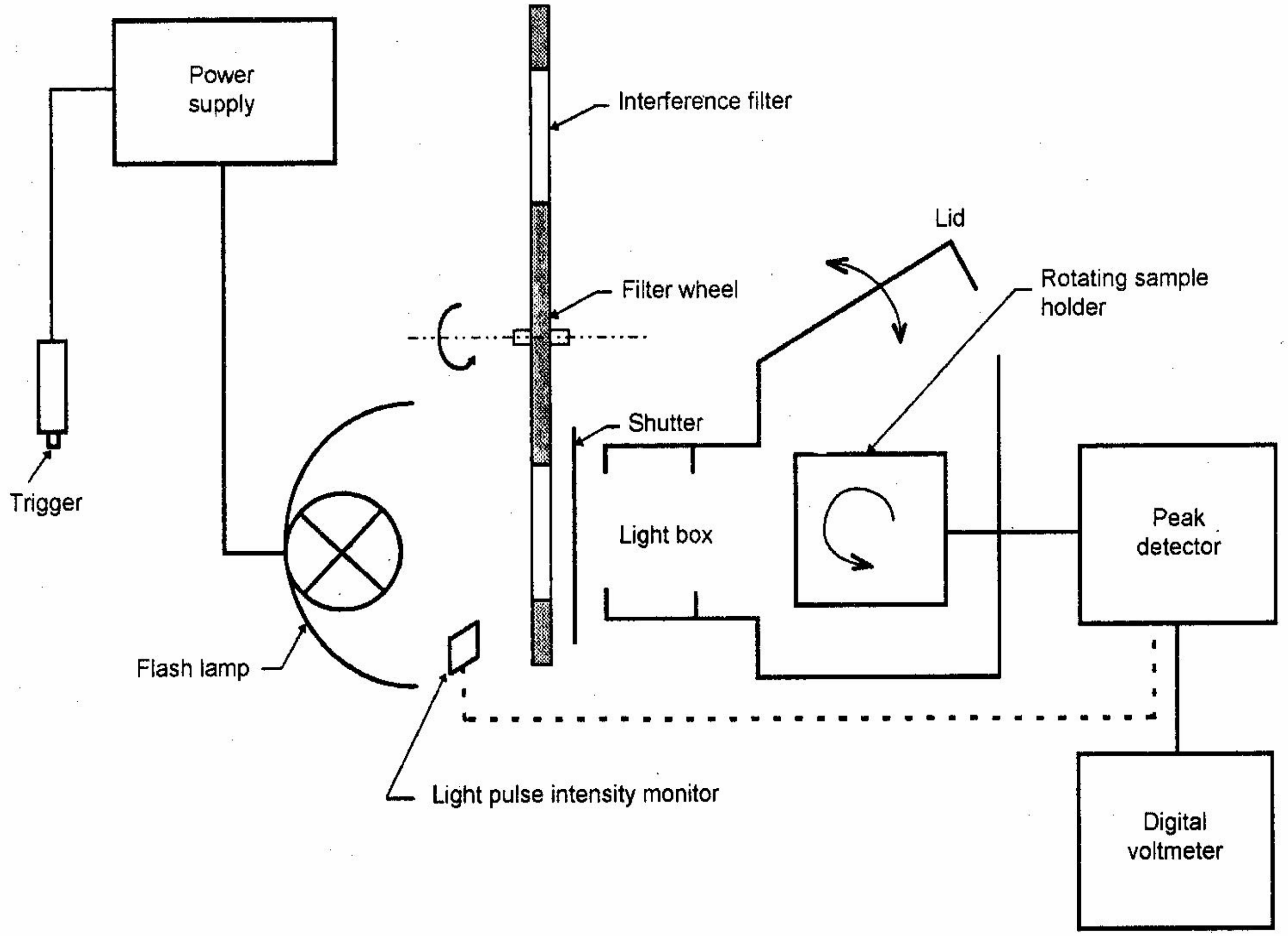

Figure 3 – Experimental test set-up for pulsed spectral response measurement

GMGIPN – 384 BIS/ND/2009 – 300

Bureau of Indian Standards

BIS is a statutory institution established under the *Bureau of Indian Standards Act,* 1986 to promote harmonious development of the activities of standardization, marking and quality certification of goods and attending to connected matters in the country.

Copyright

BIS has the copyright of all its publications. No part of the these publications may be reproduced in any form without the prior permission in writing of BIS. This does not preclude the free use, in the course of implementing the standard, of necessary details, such as symbols and sizes, type or grade designations. Enquiries relating to copyright be addressed to the Director (Publications), BIS.

Review of Indian Standards

Amendments are issued to standards as the need arises on the basis of comments. Standards are also reviewed periodically; a standard alongwith amendments is reaffirmed when such review indicates that no changes are needed; if the review indicates that changes are needed, it is taken up for revision. Users of Indian Standards should ascertain that they are in possession of the latest amendments or edition by referring to the latest issue of 'BIS Catalogue' and 'Standards: Monthly Additions'.

This Indian Standard has been developed from Doc No.: ETD 28 (6019).

Amendments Issued Since Publication

Amend No.	Date of Issue	Text Affected

BUREAU OF INDIAN STANDARDS

Headquarters:

Manak Bhavan, 9 Bahadur Shah Zafar Marg, New Delhi 110002
Telephones: 2323 0131, 2323 3375, 2323 9402 *Website*: www.bis.org.in

Regional Offices:

		Telephones
Central	Manak Bhavan, 9 Bahadur Shah Zafar Marg NEW DELHI 110002	2323 7617 2323 3841
Eastern	1/14 C.I.T. Scheme VII M, V.I.P. Road, Kankurgachi KOLKATA 700054	2337 8499, 2337 8561 2337 8626, 2337 9120
Northern	SCO 335-336, Sector 34-A, CHANDIGARH 160022	260 3843 260 9285
Southern	C.I.T. Campus, IV Cross Road, CHENNAI 600113	2254 1216, 2254 1442 2254 2519, 2254 2315
Western	Manakalaya, E9 MIDC, Marol, Andheri (East) MUMBAI 400093	2832 9295, 2832 7858 2832 7891, 2832 7892

Branches : AHMEDABAD. BANGALORE. BHOPAL. BHUBANESHWAR. COIMBATORE. DEHRADUN. FARIDABAD. GHAZIABAD. GUWAHATI. HYDERABAD. JAIPUR. KANPUR. LUCKNOW. NAGPUR. PARWANOO. PATNA. PUNE. RAJKOT. THIRUVANANTHAPURAM. VISAKHAPATNAM.

PRINTED BY THE GENERAL MANAGER, GOVT. OF INDIA PRESS, NASHIK-422 006

–384 BIS/ND/2009